________________________Activity 12

THERE'S NO PLACE LIKE HOME, OR IS THERE?

MATERIALS

Part I
Work in small groups. Each student will need

- at least one topographic or geologic map of an area on Earth
- one sample image of the Moon's surface

Part 11 Work in small groups. Each student will need

- blank map of North America (Figure 4)

WHAT IS HAPPENING?

• blank map of North America (Figure 4)

Before this lesson, activities in this book have emphasized cratering on the Moon and other planetary bodies. However, little has been said about cratering on Earth. Has Earth's surface received as many impacts as other surfaces? The present activity explores this question.

After quick examination, students will see that Earth's surface looks quite different from the Moon's. What explains this contrast? Has Earth received fewer impacts? As a matter of fact, on the basis of many studies, astronomers believe Earth receives 20 times the number of impacts as does the Moon. However, the impact rate per square kilometer is nearly the same. (Earth is a bigger target in terms of its surface area and its gravitational pull.) This being the case, if few craters can be found on Earth, the question becomes: where is the evidence of impacts?

Earth is a dynamic planet. Weather alters its surface through wind, water, heating, and cooling. Tectonic activity creates, alters, and destroys surfaces. It also covers and otherwise obliterates surface features—as can glaciers and changes in sea level, among other things. Such geological processes remove evidence of impacts. The age of a surface also is important to the study of cratering. The longer a surface is exposed, the more likely it is to have evidence of impacts. The Moon 's heavily cratered surface is at least 2 billion years old and probably records 3 to 4 billion years of impacts. Most of Earth's surface is *considerably* younger than this. Most surface features, such as mountains and plains, are 50 to 500 million years old. No wonder Earth has fewer craters!

IMPORTANT POINTS FOR STUDENTS TO UNDERSTAND

- When it comes to impacts, Earth is *not* unique. Many bolides have collided with our planet over its 4.6 billion year history. Impact sites are known on all seven continents.

• Geological processes—like erosion, weathering and plate tectonics—have obscured and destroy evidence of many impacts on Earth's surface. Similar processes do not occur on the Moon.

• The number of impacts on a surface depends mostly on the amount of time that surface is exposed. Surfaces exposed for longer periods usually show evidence of more impacts.

VITY 12

DATA TABLE 3

A sample of Earth's largest impact sites

SIZE (KM)	AGE (MILLION YEARS AGO)	LOCATION
140	1,840	Sudbury, Ontario, Canada
140	1,970	Vredefort, South Africa
100	40	Popigai, Siberia, Russia
80	183	Puchezh-Katunki, Russia
70	210	Manicouagan, Quebec, Canada
50	57	Kara, Russia
52	365	Slijan, Sweden
46	360	Charlevoix, Canada
40	<250	Araguainha Dome, Brazil

Source: Grieve, 1982, "The Geological Record of Impacts," in L.T. Silver and P.H. Schultz, "Geological Implications of Large Asteroids and Comets on the Earth," GSA Special Paper 190.

PREPARATION

When selecting maps, your choice of geographical region is not as important as the map's scale. You want the maps to-show enough detail that craters can be identified. Scales no smaller than 1 centimeter equals 10 to 20 kilometers should be used. Tourist maps and road atlases are barely adequate because they identify almost no craters except Arizona's Barringer Crater. Try topographic or geologic maps. Photographs of Earth taken by satellites are another option. Available from NASA, these photos can reveal that craters are hard to find on Earth.

Many types of maps—topographic and otherwise—can be obtained from the U.S. Geological Survey. For images of the Moon, use images supplied in Activity 2 (which also are available on Craters!-CD). Because students need only make qualitative comparisons, these can just be posted. If you want quantitative comparisons, copy images for each student.

Your choice of region can coincide with other geographical projects on which students are working. Good results can be obtained by focusing on eastern Canada, western Australia, and western China. Locations of particularly large craters are given in Data Table 3. Major crater sites in North America are listed in Data Table 1. To keep student interest, be sure to use maps on which craters are easy to find. However, because impacts are relatively rare on Earth, be sure most students obtain negative results. Learning why craters are relatively rare on Earth is the goal of this activity.

Part II of this activity examines impact sites in North America. Be sure to make tne point that craters are known on all seven continents. The Resources List provides sources for surveys of impacts on other continents.

SUGGESTIONS FOR FURTHER STUDY

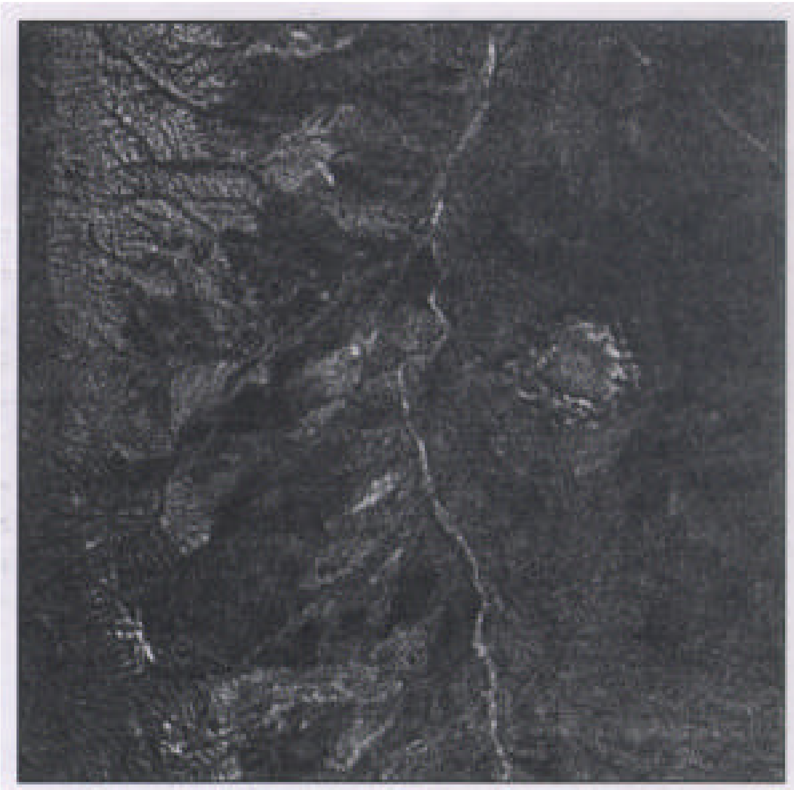
This activity provides a convenient launching point to discuss many geological processes—e.g., erosion, weathering, volcanism, and plate tectonics. Students can experiment with the effects of weathering, for example, on crater shape by placing a crater model outside for an extended period of time. They could also make a model crater and subject it to "rain" and other types of weathering.

This activity intentionally skips over questions about the relative rate of impacts over time. Some astronomers believe many more impacts occurred during the Solar System's earliest times. As the amount of debris was reduced, impact rates dropped dramatically. (Compare, for instance, high crater densities on 4 billion-yearold, highly cratered lunar surfaces with low crater densities on 3.5 billion-year-old lunar lava plains. See Activity 6.) Other astronomers believe impact rates fluctuate periodically, with planetary bodies sometimes exposed to high impact rates and other times exposed to low impact rates. Students can investigate these different interpretations, the evidence for them, and how each interpretation affects our understanding of Earth's history of impacts. A recent article by G. Jeffrey Taylor in Scientif c American (see Resources List) provides an excellent starting point. That article also raises questions about the origin of the Moon. The theory currently most widely accepted indicates that the Moon formed from debris blown into space by an enormous impact on a very young Earth.

CONNECTIONS

Students can compare crater distributions on geologically active planetary bodies (c.g., Earth and Venus) with geologically inactive ones (e.g., the Moon and Mars).

To investigate the early history of observations of meteors; nd metcorites, sec the paper by Ursula Marvin in the Resources List.



Gosses Bluff, in the arid Missionary Plain in the

Northern Temtories, Australia, is a highly eroded impact site, with a rim diameter of 22 km. Gosses Bluff is approximately 142.5 million years old

(+/- 0.5 million years). On Craters!-CD this is file Earth 122. tif

ANSWERS TO QUESTIONS FOR STUDENTS

Part I

1. Regardless of which Moon photographs you use, students should conclude that craters are much less frequent on Earth than on the Moon. Encourage quantitative comparisons.

2. Answers will vary but encourage ideas that can be realistically tested. Popular answers include

- Crater frequency is different between Earth and the Moon

because of sampling errors—the craters expected to be on Earth simply exist in places where students have not looked.
Test this by changing the sample.

• Earth's surface is mostly water, so that's where impacts occur. Test this be studying crater distribution on other planetary bodies. Compare patterns of distribution.

• Impact rates are not the same on the two planetary bodies. Test this with a survey of impact frequencies for many planetary bodies.

• Impact rates are the same, but many craters on Earth disappear after they are formed. Test this by identifying eroded or obliterated craters. Also study how geological processes remove evidence of impacts.

3. Much of Earth's surface is covered with water. It also is exposed to weathering and erosion processes. Furthermore, geological activity creates new surfaces and destroys others. Earth also has an atmosphere which provides enough friction to burn up smaller incoming meteors.

4. Barringer Crater is in northern Arizona; Clearwater Lakes are in Quebec, Canada. At nearly 300 million years old, Clearwater Lakes craters are perhaps 60 times as old as Barringer Crater. Quebec has more severe weathering and erosion processes at work. It also has been covered with glaciers at different times after the craters were formed. Arizona provides a more stable environment.

5. Weathering in more severe climates. Erosion from environments that are wetter. These clues help explain why craters disappear faster on Earth compared to the Moon.

DATA TABLE 2 - KEY

CRATER DIAMETER (KM)	NUMBER OBSERVED
under 2.0	3
2.0–3.9	6
4.0–7.9	9
8.0–15.9	9
16.0–31.9	6
32.0–63.9	3
64.0 and over	3

6. Students are investigating crater frequency. If impact rates on Earth were much lower than on the Moon, then the explanation for sentence (a) is relatively simple: crater frequency depends only on impact rate. But what if impacts occur on Earth at about the same frequency as they do on the Moon? The question needing explanation becomes what happens to the craters to make them relatively rare here compared to the Moon?

Part II

1. Answers will vary. Usually students are surprised to find so many craters.

2. Answers will vary.

3. The size distribution is shown in Data Table 2-Key. Many craters smaller than 7.9 km diameter have probably been lost by erosion—hence the "normal" size distribution found on the Moon or asteroids is not preserved. Craters larger than 8 km diameter are large enough that traces of most remain.

If students performed activities in Activities 6 and 7 on crater size distribution, they should have expected many more small fragments and a more nearly logarithmic pattern. More very large craters are found than expected because the smallest craters are more easily obliterated than larger ones. Thus, larger craters persist for unusually long periods of time. This distorts the results.

e RATE Rtl 1 O ¢

DATA TABLE 2 - KEY

CRATER DIAMETER (KM)	NUMBER OBSERVED
under 2.0	3
2.0–3.9	6
4.0–7.9	9
8.0–15.9	9
16.0–31.9	6
32.0–63.9	3
64.0 and over	3